

THE SECRET OF OUR SUCCESS

How Culture Is Driving Human Evolution,
Domesticating Our Species,
and Making Us Smarter

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PRINCETON UNIVERSITY PRESS
Princeton & Oxford

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Published by Princeton University Press
41 William Street, Princeton, New Jersey 08540

In the United Kingdom: Princeton University Press
6 Oxford Street, Woodstock, Oxfordshire OX20 1TW

press.princeton.edu

Jacket art courtesy of ClipArt ETC at the Florida Center for Instructional
Technology and *Victorian Goods and Merchandise: 2,300 Illustrations*, selected and
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ISBN 978-0-691-16685-8

Library of Congress Control Number: 2015934779

British Library Cataloging-in-Publication Data is available

This book has been composed in Sabon Next LT Pro and DIN Pro

Printed on acid-free paper. ∞

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

CHAPTER 4

HOW TO MAKE A CULTURAL SPECIES

To understand why European explorers couldn't survive as hunter-gatherers while locals—even when stranded alone—could, we need to understand how populations generate cultural adaptations—the suites or packages of skills, beliefs, practices, motivations, and organizational forms that permit people to survive, and often thrive, in diverse and challenging environments. The process is—in some crucial sense—smarter than we are. Over generations, often outside of conscious awareness, individuals' choices, learned preferences, lucky mistakes, and occasional insights aggregate to produce cultural adaptations. These often-complex packages contain subtle and implicit insights that impress modern engineers and scientists (see chapter 7). We have glimpsed some of these cultural adaptations, from Inuit clothing to nardoo detoxification, and will study other such adaptations, ranging from food taboos that protect pregnant women from marine toxins to religious rituals that galvanize greater prosociality. Before getting to these, however, we need to build an understanding of cultural evolution, from the ground up, that can explain how it is that human populations end up with complexes of tools, tastes, and techniques that are honed to local environmental challenges.

This brings us to a central insight. Rather than opposing “cultural” with “evolutionary” or “biological” explanations, researchers have now developed a rich body of work showing how natural selection, acting on

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genes, has shaped our psychology in a manner that generates *nongenetic evolutionary processes* capable of producing complex cultural adaptations. Culture, and cultural evolution, are then a consequence of genetically evolved psychological adaptations for learning from other people. That is, natural selection favored genes for building brains with abilities to learn from others. These learning abilities, when operating in populations and over time, can give rise to subtly adaptive behavioral repertoires, including those related to fancy tools and large bodies of knowledge about plants and animals. These emergent products arose initially as unintended consequences of the interaction of learning minds in populations, over time. With this intellectual move, “cultural explanations” become but one type of “evolutionary explanation,” among a potential host of other noncultural explanations.

In their now classic treatise, *Culture and the Evolutionary Process*, Rob Boyd and Pete Richerson laid the foundations of this approach by developing a body of mathematical models that explore our capacities for cultural learning as genetically evolved psychological adaptations. Once cultural learning is approached as a psychological adaptation or as a suite of adaptations, we can then ask how natural selection has shaped our psychology and motivations so as to allow us to most effectively acquire useful practices, beliefs, ideas, and preferences from others.¹ These are questions about *who* we should learn from, and *what* we should attend to and infer, as well as *when* input from cultural learning should overrule our own direct experience or instincts.

Evidence from diverse scientific fields is now revealing how finely tuned our psychological adaptations for cultural learning are. Natural selection has equipped our species with a wide range of mental abilities that allow us to effectively and efficiently acquire information from the minds and behaviors of other people. These learning instincts emerge early, in infants and young children, and generally operate unconsciously and automatically. In many circumstances, as we saw in the Matching Pennies Game and Rock-Paper-Scissors, we find it difficult to inhibit our automatic imitative instincts. As we’ll see below, even when getting “right answers” is important, our cultural learning mechanisms fire up, to influence our practices, strategies, beliefs, and motivations. In fact, sometimes the more important getting the right answer is, the more we rely on cultural learning.

As a point of departure, it is worth considering how pervasive the effects of cultural learning are on our behavior and psychology. Box 4.1 lists just some of the domains where the influence of cultural learning

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has been studied.² The list includes domains of distinct evolutionary importance, such as food preferences, mate choice, technological adoptions, and suicide, as well as social motivations related to altruism and fairness. As we'll see in later chapters, cultural learning reaches directly into our brains and changes the *neurological values* we place on things and people, and in doing so, it also sets the standards by which we judge ourselves. One classic set of experiments shows that children acquire the performance standards by which they are willing or unwilling to reward themselves.³ Children saw a demonstrator rewarding himself or herself with M&Ms only after exceeding either a relatively higher score in a bowling game or a relatively lower score. The children copied the rewarding standards of the demonstrator such that the kids exposed to the “high standards” model tended not to eat the M&Ms unless their score exceeded the higher threshold. As will become clear, culturally acquired standards or values guide our efforts and persistence at individual learning, training, and trial-and-error learning.

Box 4.1: Domains of Cultural Learning

- Food preferences and quantity eaten
- Mate choices (individuals and their traits)
- Economic strategies (investments)
- Artifact (tool) functions and use
- Suicide (decision and method)
- Technological adoptions
- Word meanings and dialect
- Categories (“dangerous animals”)
- Beliefs (e.g., about gods, germs, etc.)
- Social norms (taboos, rituals, tipping)
- Standards of reward and punishment
- Social motivations (altruism and fairness)
- Self-regulation
- Judgment heuristics

Let's begin by exploring how thinking of our cultural learning abilities as genetically evolved psychological adaptations deepens our understanding of both how we adapt to our worlds as individuals and how populations adapt to their environments over generations. Our first

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question is: how should individuals figure out *whom* to learn from? This question is crucial because it will illuminate how cultural adaptations can emerge.

Suppose you are a boy living in a hunter-gatherer band. To survive, the men in your community hunt a wide range of game. How should you go about hunting? You could just start experimenting. Maybe try throwing rocks at gazelles or chasing some zebras. Or you could wait for some evolved instincts for hunting to fire up and tell you what to do. If you go this route, you'll probably wait a long time, as this is the situation that Franklin, Burke, and Narváez found themselves in. Franklin's men lived for nineteen months on the pack ice with starvation looming, but no one figured out how to harpoon a seal. In fact, since you are a member of a cultural species, your instincts will fire up, but instead of supplying specialized hunting abilities, they will cause you to start looking for people to copy—but not just any people. Aspiring young hunters first glean as much as they can from those to whom they have ready access, like their brothers, fathers, and uncles. Later, perhaps during adolescence, learners update and improve their earlier efforts by focusing on and learning from the older, most successful, and most prestigious hunters in their community. That is, learners should use three cultural learning cues to target their learning: age, success, and prestige. You might also use “being male” as a cue, since, let's assume, hunting is predominantly a male activity. These cues will not only help you zoom in on those in your community most likely to possess adaptive practices, routines, beliefs, and skills related to hunting, but will also allow you to gradually scaffold up your abilities and know-how while making the most of what those who care about you know. Moreover, since particular individuals may be successful or prestigious for idiosyncratic reasons (like possessing good genes), you'll want to sample several of the top hunters and use only those practices preferred by a plurality of them.⁴

More broadly, evolutionary reasoning suggests that learners should use a wide range of cues to figure out whom to selectively pay attention to and learn from. Such cues allow them to target those people most likely to possess information that will increase the learner's survival and reproduction. In weighting the importance of those they can potentially learn from (hereafter their *models*), individuals should combine cues related to the models' health, happiness, skill, reliability, competence, success, age, and prestige, as well as correlated cues like displays of confidence or pride. These cues should be integrated with others related to self-similarity, such as sex, temperament, or ethnicity (cued by, e.g., lan-

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guage, dialect, or dress). Self-similarity cues help learners focus on those likely to possess cultural traits (e.g., practices or preferences) that will be useful to the learner in their future roles. Same-sex cues, for example, reduce the time spent by teenage boys attending to the details of many female-specific activities, such as how to latch an infant, or what to do when a viscous, yellowish secretion (colostrum) first emerges from the nipple after birth. Together, all of these cues provide input to “model-based” cultural learning mechanisms because they help individuals figure out from whom to learn. Let’s take a closer look at our selective cultural learning.

Skill and Success

Since many model-based cues, such as success and prestige, are only loosely tied to particular domains of behavior, such as hunting or golf, we expect them to influence learning about a broad spectrum of cultural traits, ranging from preferences for food, mates, wine, and linguistic labels to beliefs about invisible agents or forces, like gods, germs, angels, karma, and gravity. This is not to say that we should expect the same cues to have the same size impact on very different domains. What makes someone a successful hunter or basketball player is surely better predicted by their arrow-making techniques or their jump-shot form, respectively, but may also be impacted by the practice of eating carrots or by saying a brief prayer before heading out to hunt or play basketball. Eating carrots might improve a shooter’s vision while a prayer ritual might calm and focus the mind (or, possibly bring supernatural aid).

Let’s begin by looking more deeply at the impact of cues related to skill and success, which capture notions of competence and reliability. Skill cues are those that relate most directly to competence in a domain. For example, one might assess a writer’s skill by reading his books. In a foraging society, an aspiring hunter might watch an older hunter adeptly stalk a giraffe, crouch in a tree’s shadow, and fluidly release an accurately targeted arrow. By contrast, success cues are more indirect, but potentially more useful, because they aggregate information. Using success cues, you might evaluate a writer on the number of copies that his book sells, and a hunter by the frequency with which he brings home big game. Since many hunting societies have practices that facilitate easy accounting of prior kills, you might be able to look at how many monkey teeth a hunter has on his necklace or at the number of pig mandibles hung outside of his house.⁵

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To see the power and pervasiveness of the use of success cues in cultural learning, consider the following experiment. MBA students participated in two different versions of an investment game. In the game, they had to allocate their money across three different investment options, labeled A, B, and C. They were told each investment's average monetary returns and its variation (sometimes you get more than average, other times, less). They were also told the relationships or correlations among the investments; for example, if investment A's value goes up, then B's value tends to go down. Participants could borrow money to invest. During each round of the game, each player would make his or her allocations and receive the returns. After each round, players could alter their investment allocations for the next round, and this went on for sixteen rounds. At the end of the game, each player's portfolio performance ranking relative to the other players heavily influenced their grade in the course, moving it up or down. If you know any MBAs, you'll know this is a serious incentive, and these players were thus strongly motivated to make the most money in the game.

The experimenters randomly assigned players to one of two different versions, or treatments. In one version, the MBAs made their decisions in isolation, receiving only the individual experience derived from their own choices over the sixteen rounds. The other version was identical except that the allocations chosen and performance rankings of all participants were posted between each round, using anonymous labels.

The difference in the results from each version surprised the economists who designed the experiment (though, admittedly, many economists are pretty easily surprised by human behavior⁶). Three patterns are striking. First, the MBAs didn't use the additional information available in the second treatment (with posted performances) in the complex and sophisticated way economic theory assumes. Instead, careful analysis shows that many participants were merely copying ("mimicking") the investment allocations made by the top performers in the previous round. Second, the environment of this experiment is simple enough that one can actually calculate the profit-maximizing investment allocations. This optimal allocation can be compared with where participants actually ended up in round 16 for each of the two versions. Left only to their own individual experience, the MBAs ended up very far away from the optimal allocation—thus, poor overall performance. However, in the second treatment, when they mimicked each other's investments, the group zeroed in on the optimal allocation by the end of the game. Here, the whole group made more money, which is interesting since

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there were no incentives for group performance, as grade assignments were all based on relative rankings. Finally, while opportunities to imitate each other had a dramatic effect on improving the overall group performance, it also led to some individual catastrophes. Sometimes top performers had taken large risks, which paid off in the short run—they got lucky. But their risky allocations, which often included massive borrowing, were copied by others. Since you can't copy the luck along with the allocation choices, an inflated number of bankruptcies resulted as a side effect.⁷

The central finding of this experiment, that people are inclined to copy more successful others, has been repeatedly observed in an immense variety of domains, both in controlled laboratory conditions and in real-world patterns.⁸ In experiments, undergraduates rely on *success-biased* learning when real money is on the line—when they are paid for correct answers or superior performance. In fact, the more challenging the problem or the greater the uncertainty, the more inclined people are to rely on cultural learning, as predicted by evolutionary models. This tells us something about *when* individuals will rely on cultural learning over their own direct experience or intuitions.⁹

Interestingly, if you are a real stock market investor, this is now a formal strategy: you can purchase exchange-traded funds (ETFs) that match the picks of the market gurus (GURU), billionaire investors (iBillionaire), or the top money managers (ALFA).¹⁰ But remember, you can't copy their luck.

Experimentally, economists have also shown that people rely on this skill- or success-biased cultural learning to (1) infer and copy others' beliefs about the state of the world, even when others have identical information, and (2) adapt to competitive situations, where copying others is far from the optimal strategy. In the real world, farmers from around the globe adopt new technologies, practices, and crops from their more successful neighbors.¹¹

Running in parallel with the work in economics, decades of work by psychologists has also shown the importance of success and skill biases. This work underlines the point that these learning mechanisms operate outside conscious awareness and with or without incentives for correct answers.¹² One set of recent experiments by Alex Mesoudi and his collaborators are particularly relevant for our focus here on complex technologies.¹³ In his arrowhead design task, participants engaged in repeated rounds of trial-and-error learning using different arrowhead designs to engage in virtual hunting on a computer. When-

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ever the opportunities were made available, students readily used success-biased cultural learning to help design their arrowheads. When cultural information was available, it rapidly led the group to the optimal arrowhead design and was most effective in more complex, more realistic environments.

In the last fifteen years, an important complementary line of evidence has become available as developmental psychologists have returned to focusing on cultural learning in children and infants. With new evolutionary thinking in the air, they have zoomed in on testing specific ideas about the *who*, *when*, and *what* of cultural learning. It's now clear that infants and young children use cues of competence and reliability, along with familiarity, to figure out from whom to learn. In fact, by age one, infants use their own early cultural knowledge to figure out who tends to know things, and then use this performance information to focus their learning, attention, and memory.

Infants are well known to engage in what developmental psychologists call "social referencing." When an infant, or young child, encounters something novel, say when crawling up to a chainsaw, they will often look at their mom, or some other adult in the room, to check for an emotional reaction. If the attending adult shows positive affect, they often proceed to investigate the novel object. If the adult shows fear or concern, they back off. This occurs even if the attending adult is a stranger. In one experiment, mothers brought one-year-olds to the laboratory at Seoul National University. The infants were allowed to play and get comfortable in the new environment, while mom received training for her role in the experiment. The researchers had selected three categories of toys, those to which infants typically react (1) positively, (2) negatively, and (3) with uncertain curiosity (an ambiguous toy). These different kinds of toys were each placed in front of the infants, one at a time, and the infant's reactions were recorded. Mom and a female stranger sat on either side of the baby and were instructed to react either with smiling and excitement or with fear.

The results of this study are strikingly parallel to studies of cultural learning among both young children and university students. First, the babies engaged in social referencing, looking at one of the adults, four times more often, and more quickly, when an ambiguous toy was placed in front of them. That is, under uncertainty, they used cultural learning. This is precisely what an evolutionary approach predicts for *when* individuals should use cultural learning (see note 9). Second, when faced with an ambiguous toy, babies altered their behavior based on the

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adults' emotional reactions: when they saw fear, they backed off, but when they saw happiness, they approached the toy and changed to regard it more positively. Third, infants tended to reference the stranger more than their moms, probably because mom herself was new to this environment and was thus judged less competent by her baby.¹⁴

By 14 months, infants are already well beyond social referencing and already showing signs of using skill or competence cues to select models. After observing an adult model acting confused by shoes, placing them on his hands, German infants tended not to copy his unusual way of turning on a novel lighting device: using his head. However, if the model acted competently, confidently putting shoes on his feet, babies tended to copy the model and used their heads to activate the novel lighting device.¹⁵

Later, by age three, a substantial amount of work shows that children not only track and use competence in their immediate cultural learning but retain this information to selectively target their future learning in multiple domains. For example, young children will note who knows the correct linguistic labels for common objects (like “ducks”), use this information for targeting their learning about both novel tools or words, and then remember this competence information for a week, using it to preferentially learn new things from the previously more competent model.¹⁶

Prestige

By observing whom others watch, listen to, defer to, hang-around, and imitate, learners can more effectively figure out from whom to learn. Using these “prestige cues” allows learners to take advantage of the fact that other people also are seeking, and have obtained, insights about who in the local community is likely to possess useful, adaptive information. Once people have identified a person as worthy of learning from, perhaps because they've learned about their success, they necessarily need to be around them, watching, listening, and eliciting information through interaction. Since they are trying to obtain information, learners defer to their chosen models in conversation, often giving them “the floor.” And, of course, learners automatically and unconsciously imitate their chosen models, including by matching their speech patterns (see chapter 8). Thus, we humans are sensitive to a set of ethological patterns (bodily postures or displays), including visual attention, “holding the floor,” deference in conversation, and vocal mimicry, as well as

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others. We use these prestige cues to help us rapidly zero in on whom to learn from. In essence, prestige cues represent a kind of second-order cultural learning in which we figure out who to learn from by inferring from the behavior of others who they think are worthy of learning from—that is, we culturally learn from whom to learn.

Despite the seeming ubiquity of this phenomenon in the real world, there is actually relatively little direct experimental evidence that people use prestige cues. There is an immense amount of indirect evidence that shows how the prestige of a person or source, such as a newspaper or celebrity, increases the persuasiveness of what they say or the tendency of people to remember what they say. This effect occurs even when the prestige of a person comes from a domain, like golf, that is far removed from the issue they are commenting on (like automobile quality). This provides some evidence, though it does not get at the specific cues that learners might actually use to guide them, aside from being told that someone is an “expert” or “the best.”¹⁷

To address this in our laboratory, Maciej Chudek, Sue Birch, and I tested this prestige idea more directly. Sue is a developmental psychologist and Maciej was my graduate student (he did all the real work). We had preschoolers watch a video in which they saw two different potential models use the same object in one of two different ways. In the video, two bystanders entered, looked at both models, and then preferentially watched one of them. The visual attention of the bystanders provided a “prestige cue” that seemingly marked one of the two potential models. Then, participants saw each model select one of two different types of unfamiliar foods and one of two differently colored beverages. They also saw each model use a toy in one of two distinct ways. After the video, the kids were permitted to select one of the two novel foods and one of the two colorful beverages. They could also use the toy any way they wanted. Children were 13 times more likely to use the toy in the same manner as the prestige-cued model compared to the other model. They were also about 4 times more likely to select the food or beverage preferred by the prestige-cued model. Based on questions asked at the end of the experiment, the children had no conscious or expressible awareness of the prestige cues or their effects. These experiments show that young children rapidly and unconsciously tune into the visual attention of others and use it to direct their cultural learning. We are prestige biased, as well as being skill and success biased.¹⁸

Chapter 8 expands on these ideas to explore how selective cultural learning drove the evolution of a second form of social status in humans

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called Prestige, which in our species resides alongside the Dominance status we inherited from our primate ancestors. We'll see why, for example, it is possible to become famous for being famous in the modern world.

Self-Similarity: Sex and Ethnicity

Automatically and unconsciously, people also use cues of self-similarity, like sex and ethnicity, to further hone and personalize their cultural learning. Self-similarity cues help learners acquire the skills, practices, beliefs, and motivations that are, or were in our evolutionary past, most likely to be suitable to them, their talents, or their probable roles later in life. For example, many anthropologists argue that the division of labor between males and females is hundreds of thousands of years old in our species' lineage. If true, we should expect males to preferentially hang around, attend to, and learn from other males—and vice versa for females. This will result in novices learning the skills and expectations required for their likely roles later in life, as mothers, hunters, cooks, and weavers. Similarly, since individual differences, like height or personality, might influence one's success in various endeavors, learners may preferentially attend to those whom they resemble along these dimensions. In chapter 11, I will further detail the evolutionary logic underpinning the prediction that learners should preferentially attend to, and learn from, those who share their ethnic-group markers, such as language, dialect, beliefs, and food preferences. In short, these cues allow learners to focus on those most likely to possess the social norms, symbols, and practices that the learners will need over their life course for successful and coordinated social interactions.

There is ample evidence from psychological experiments—going back forty years—that both children and adults preferentially interact with, and learn from, same-sex models over opposite-sex models. In young children, these biases emerge even before they develop a gender identity and influence their learning from parents, teachers, peers, strangers, and celebrities. In fact, children learn their sex roles because they copy same-sex models, not vice versa. Evidence indicates that this learning bias influences diverse cultural domains, including musical tastes, aggression, postures, and object preferences. Later, we'll see that in the real world, it influences both students' learning (and performance) as well as patterns of copycat suicide.¹⁹

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Recent work by the brain scientist Elizabeth Reynolds Losin, a former student of mine, and her colleagues at UCLA has begun to illuminate the neurological underpinnings of sex-biased cultural learning. Using fMRI technology, Liz focused on the difference between people's brains when they imitated a same-sex model versus an opposite-sex model. She asked both men and women in Los Angeles to first watch and then imitate the arbitrary hand gestures either of a same-sex or opposite-sex model. By comparing the same individuals' brain activity while watching versus watching and imitating both same- and opposite-sex models, Liz showed that women find mimicking other women more rewarding—neurologically speaking—than mimicking men. Men showed the opposite pattern. When people copied same-sex models, firing activity was higher in the nucleus accumbens, dorsal and ventral striatum, orbital frontal cortex, and left amygdala. Her analysis of the existing database of brain studies reveals that this pattern of brain activity emerges when people receive a reward, such as money, for getting the correct answer. This finding suggests that we experience copying same-sex others as internally more rewarding than copying opposite-sex others. We like it more, so naturally we are inclined to do it more.

While research on ethnicity biases in cultural learning is more limited, it's increasingly clear that infants, young children, and adults preferentially learn from co-ethnics—meaning that people attend to and selectively learn from those who share their ethnic markers. Young children preferentially acquire both food preferences and the functions of novel objects from those who share their language or dialect. This is true even when the potential models speak jabberwocky—English-sounding speech composed of nonsense words. That is, kids prefer to learn from those speaking nonsense *in their own dialect* rather than from someone speaking nonsense in a different dialect (suddenly, I'm reminded of much American political discourse). Infants preferentially copy the more unusual and difficult action—turning on a lamp with their head—from someone who speaks their language (German) as opposed to an unfamiliar language (Russian). And children and adults prefer to learn from those who already share some of their beliefs.²⁰

These laboratory findings suggest that cues related to sex and ethnicity fire up our cultural learning psychology in ways that spark our interest in what the model is doing, or talking about, and focus our attention and memory. If true, students may learn more effectively from teachers or professors who match them on these dimensions, which may impact

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a person's grades, choice of major, or career preferences. Formal education is, after all, primarily an institution for intensive cultural transmission. Of course, identifying this learning bias as a causal influence is tricky in the real world because teachers have biases too, which may lead them to preferentially assist or reward those who share their sex or ethnic markers. Isolating causality in the real world is what economists are best at, so let's bring in some economists.

By exploiting large data sets of students, courses, and instructors, my UBC colleague Florian Hoffman and his collaborators unearthed real-world evidence consistent with the experimental findings discussed above: being taught by instructors whom you match on ethnicity/race reduces your dropout rate and raises your grades. In fact, for African-American students at a community college, being taught by an African-American instructor reduced class dropout rates by 6 percentage points and increased the fraction attaining a B or better by 13 percentage points. Similarly, using data from freshman (first-years) at the University of Toronto, Florian's team has also shown that getting assigned to a same-sex instructor increased students' grades a bit.

Unlike many researchers before them, Florian and his colleagues addressed concerns that these patterns are created by the instructors' biases by focusing on large undergraduate lectures where students (1) could not influence which instructors they got, (2) were anonymous to the professor, and (3) were graded by teaching assistants, not by the professors.²¹ All this points to biases that influence whom learners readily tune in to and learn from.

Our cultural learning biases are why role models matter so much.

Older Individuals Often Do Know More

Both as an indirect measure of competence or experience, and as a measure of self-similarity, age cues may be important for cultural learning for two separate evolutionary reasons. For children, focusing on and learning from older children allows them to learn from more experienced individuals while at the same time providing a means of self-scaffolding, allowing them to bridge gradually from less to more complex skills. The idea here is that although a learner may be able to locate, and sometimes learn from, the most successful or skilled person in his community (say, the best hunter in a foraging band), many young learners will be too inexperienced or ill-equipped to take advantage of the

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nuances and fine points that distinguish the top hunters. Instead, by focusing on older children, young learners can isolate models who are operating at an appropriate increment of skill and complexity above their own. This creates a smoother and more continuous process of gradual skill acquisition, as learners move back and forth from observing older models to practicing, and repeat the process as they grow up. This is why, for example, younger children are often so desperate to hang around their “big cousins” or older siblings, and why mixed-age playgroups are the standard in small-scale societies.

Consistent with evolutionary expectations, young children do assess the age of potential models, perhaps by assessing physical size. Young children often prefer older models unless those individuals have proven unreliable. They trade off *age* against *competence* and in some cases will prefer younger but more competent models to older, less competent ones. For example, in one experiment second graders preferentially imitated the fruit choices of their fellow second graders over kindergarten models. However, when shown that some kindergarteners and second graders were superior puzzle solvers, many second graders shifted to the fruit choices of these good puzzle solvers, even if they were sometimes kindergarteners. In general, children and infants shift their food preferences in response to observing older, same-sex, models enjoying certain foods. Even infants, as young as 14 months, are sensitive to age cues.²²

At the other end of the age spectrum, merely getting to be old was a major accomplishment in the societies of our evolutionary past. By the time ancient hunter-gatherers reached 65, and some did, natural selection had already filtered many out of their cohort. This means that not only were the senior members of a community the most experienced, but also that they had emerged from decades of natural selection acting selectively to shrink their age cohort. To see how this works, imagine you have a community with 100 people between the ages of 20 and 30. Of these 100, only 40 people routinely prepare their meat dishes using chili peppers. Suppose that using chili peppers, by virtue of their antimicrobial properties, suppresses food-borne pathogens and thereby reduces a person's chances of getting sick. If eating chili peppers year after year increases a person's chances of living past 65 from 10% to 20%, then a majority of this cohort, 57%, will be chili-pepper eaters by the time they reach 65. If learners preferentially copy the older cohort, instead of the younger cohort, they will have a greater chance of acquiring this

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survival-enhancing cultural trait. This is true even if they have no idea that chili peppers have any health impacts (see chapter 7). Age-biased cultural learning here can thus amplify the action of natural selection, as it creates differential mortality.²³

Why Care What Others Think? Conformist Transmission

Suppose you are in a foreign city, hungry, and trying to pick one of ten possible restaurants on a busy street. You can't read the menus because you don't know the local language, but you can tell that the prices and atmospheres of each establishment are identical. One place has 40 diners, six have 10 diners, and three are empty, except for the waitstaff. If you would pick the restaurant with 40 people (out of the 100 you've observed) *more than* 40% of the time then you are using conformist transmission—you are strongly inclined to copy the most common trait—the majority or the plurality.

Evolutionary models, which are built to mathematically capture the logic of natural selection, predict that learners ought to use what's called *conformist transmission* to tackle a variety of learning problems. As long as individual learning, intuitions, direct experience, and other cultural learning mechanisms tend to produce adaptive practices, beliefs, and motivations, then conformist transmission can help learners aggregate the information that is distributed across a group. For example, suppose long experience fishing will tend to cause anglers to prefer the blood knot to other potential knots (for connecting monofilament line) because the blood knot is objectively the best. However, individual experiences will vary, so suppose that long experience alone leads to only a 50% chance of an angler converging on the blood knot, a 30% chance of using the fisherman's knot, and a 20% chance of using one of five other knots. A conformist learner can exploit this situation and jump directly to the blood knot without experience. Thus, the wisdom of crowds is built into our psychology.

There is some laboratory evidence for conformist transmission, both in humans and sticklebacks (a fish), though there is not nearly as much as for the model-based cues discussed above. Nevertheless, when problems are difficult, uncertainty is high, or payoffs are on the line, people tend to use conformist transmission.²⁴

Of course, we should expect learners to combine the learning heuristics I've described. For example, with regard to chili peppers, learners

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who apply conformist transmission to only the older cohort (sorting with age cues) will increase their chances of adopting this adaptive practice. If they are strong conformist learners, they will get the adaptive answer 100% of the time.

Culturally Transmitted Suicide

You probably know that committing suicide is prestige biased: when celebrities commit suicide there is a spike in suicide rates (celebrities: keep this in mind!). This pattern has been observed in the United States, Germany, Australia, South Korea, and Japan, among other countries. Alongside prestige, the cultural transmission of suicide is also influenced by self-similarity cues. The individuals who kill themselves soon after celebrities tend to match their models on sex, age, and ethnicity. Moreover, it's not just that a celebrity suicide vaguely triggers the suicide of others. We know that people are imitating because they copy not only the act of suicide itself but also the specific methods used, such as throwing oneself in front of a train. Moreover, most celebrity-induced copycat suicides are *not tragedies that would have occurred anyway*. If that were the case, there would be an eventual dip in suicide rates below the long-run average at some point after the spike, but there is not.²⁵ These are extra suicides that otherwise would not have occurred.

These effects can also be seen in suicide epidemics. Beginning in 1960, a striking pattern of suicide rippled through the pacific islands of Micronesia for about twenty-five years. As the epidemic spread, the suicides assumed a distinct pattern. The typical victim was a young male between 15 and 24 (modal age of 18) who still lived with his parents. After a disagreement with his parents or girlfriend, the victim experienced a vision in which past victims beckoned for him to come to them (we know this from attempted suicides). In heeding their call, the victim performed a "lean hanging," sometimes in an abandoned house. In a lean hanging, victims lean into the noose from a standing or kneeling position. This gradually depletes the victim's supply of oxygen, resulting in a loss of consciousness and then death. These suicides occurred in localized and sporadic outbreaks among socially interconnected adolescents and young men, a pattern common elsewhere. Sometimes these epidemics could be traced to a particular spark, such as the suicide of a 29-year-old prominent son of a wealthy family. In 75% of the cases, there was no prior hint of suicide or depression. Interestingly, these epidemics were restricted to only two ethnic groups within Micronesia, the Trukese

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and Marshalllese.²⁶ Here we see that prestige and self-similarity, including both sex and ethnicity, shaped the diffusion of suicide.

While most people don't copy suicide, this domain illustrates just how potent our cultural learning abilities can be and how they influence broad social patterns. If people will acquire suicidal behavior via cultural learning, it's not clear what the boundaries are on the power of culture in our species. Copying suicide highlights the potency of our imitative tendencies and means that under the right conditions we can acquire practices via cultural learning that natural selection has directly acted to eliminate under most conditions. If humans will imitate something that is so starkly not in our self-interest, or that of our genes, imagine all the other less costly things we are willing to acquire by cultural transmission.

In addition to using model-based mechanisms for cultural learning, we should also expect natural selection to have equipped us with psychological abilities and biases for learning about certain predictable content domains, such as food, fire, edible plants, animals, tools, social norms, ethnic groups, and reputations (gossip), which have probably been important over long stretches of our species' evolutionary history. Here, natural selection may have favored attention and interest in these domains, as well as inferential biases, leading to ready encoding in memory and greater learnability. In the coming chapters, we'll explore how culture-gene coevolution drove the emergence of some of these specialized cognitive abilities, or *content biases*, and examine key lines of supporting evidence.

What's Mentalizing For?

If humans are a cultural species, then one of our most crucial adaptations is our ability to keenly observe and learn from other people. Central to our cultural learning is our ability to make inferences about the goals, preferences, motivations, intentions, beliefs, and strategies in the minds of others. These cognitive abilities relate to what is variously termed *mentalizing*, or *theory of mind*. Any learners who miss the boat on mentalizing and cultural learning, or get started too late, will be at a serious disadvantage because they won't have acquired all the norms, skills, and know-how necessary to compete with other, better, cultural learners. This logic suggests that the mental machinery we need for cultural learning ought to fire up relatively early in our development. It's this mental machinery that we will rely on to figure out what to eat, how

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to communicate, whom to avoid, how to behave, which skills to practice, and much more.

Evidence from young children and infants in Western populations combined with recent cross-cultural work in Fiji, Amazonia, and China suggests that these mentalizing abilities begin to develop early and reliably across diverse human societies. By the age of roughly eight months, infants in at least some societies have developed an ability to infer intentions and goals and to recognize who likely has knowledge and who does not. Infants, for example, will copy a model's goals or intentions, such as grasping a toy, even when the model fails to achieve his goal, but they won't copy unintentional actions that create the same physical results. By the time they are toddling, children are already making sophisticated judgments about others' mental states, for example, recognizing that a potential model mislabeled a familiar object and then subsequently devaluing what that model has to say. Similarly, toddlers can figure out what aspects of context are new for their model and use this to better target their learning, even when those same aspects are familiar to the learner.²⁷

Though they agree mentalizing is important, many evolutionary researchers argue that these cognitive abilities evolved genetically in our lineage so we can better trick, manipulate, and deceive other members of our group—this is part of the Machiavellian intelligence hypothesis. The idea is that if Robin can infer Mike's goals, motivations, or beliefs, then Robin can exploit or manipulate Mike. He can outthink him and then outmaneuver him.²⁸

However, another possibility is that mentalizing first evolved in our lineage, or perhaps was re-tasked away from trickery, deception, and manipulation, so that we could better learn from others by more effectively inferring our models' underlying goals, strategies and preferences for the purpose of copying them. Mentalizing also may help us teach more effectively, since good teaching requires us to assess what learners need to know. These expectations flow from the *cultural intelligence hypothesis*.²⁹

In my psychology laboratory at UBC, our team has sought to allow these two hypotheses to face off against each other. In a novel situation, we gave young children the opportunity to deploy their mentalizing abilities either to copy the strategies of others or to exploit a hapless opponent. The results are stark: children strongly favor cultural learning over Machiavellian exploitation, even when their payoffs and personal experience point them away from copying others.

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Of course, this doesn't mean that mentalizing isn't also deployed for social strategizing, as it clearly is in chimpanzees.³⁰ But what it does imply is that in humans you first need to acquire the social norms and rules governing the world you are operating in, and only then is strategic thinking useful. In our world, successful Machiavellians must first be skilled cultural learners. You can't bend, exploit, and manipulate the rules until you first figure out what the rules are.

Learning to Learn and to Teach

The evidence from infants and young children now suggest that humans rapidly develop a heavy reliance on carefully attending to, and learning from, other people, often using their mentalizing skills, and that they readily begin using cues such as success and prestige to figure out whom to learn from. However, it seems likely that both our degree of reliance on cultural learning over our own experience or innate intuitions, as well as how heavily we weight cues of prestige or gender vis-à-vis other cues may be itself tuned by both our own direct experience and our observations of others. That is, we need to be able to calibrate these systems for the contexts we encounter in the world.³¹

The importance of both direct experience and the observation of others is particularly clear for developing teaching abilities. Teaching is the flip side of cultural learning. It occurs when the model becomes an active transmitter of information. Later I'll discuss some evidence that suggests natural selection has operated to improve our transmission or communicative abilities, especially since the evolution of languages. Nevertheless, most people are still not particularly great teachers, especially of complex tasks, concepts, or skills, so cultural evolution has produced a wide range of strategies and techniques adapted for more effectively transmitting particular types of content, such as judo, algebra, or cooking. This is one way cultural transmission increases its own fidelity—learners acquire both the skills themselves as well as techniques for transmitting them.

In the early days, when our species was just beginning to rely on cultural learning, as cultural evolution was cranking up, it may be that attending to and copying others was acquired by experience, perhaps through trial-and-error learning, because it tended to get the best answer compared to other learning strategies.³² Consistent with this idea, apes reared by humans, sometimes in human families, seem to be better at imitation compared to other apes. Importantly, however, though they

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improve relative to chimpanzees not reared by humans, they still pale in comparison to human children reared in the identical environments for the same time periods. Such evidence suggests that cultural learning may have initially developed as a response to the enriched environments created by the very earliest accumulations of cultural evolution (see chapter 16).³³ This learned increase in cultural learning would have permitted a greater accumulation of cultural know-how and further driven genetic evolution to make us better cultural learners. Now, the vast differences we observe between apes and human infants raised in the same environments suggests that the emergence of cultural learning is relatively canalized and rapid in our species, though, of course, it can still be modified by experience.³⁴

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- Phoenix 2003, Henrich and McElreath 2003, and Wills, Wills, and Farmer 1863 and two valuable websites: burkeandwills.slv.vic.gov.au and www.burkeandwills.net.au.
9. Drawn from direct transcriptions of Will's posthumously published journal, the first part of the quotation comes from the entry on June 20, 1861, and the second is from the final entry, which was dated June 26 but may be as late as June 28, 1861. See www.burkeandwills.net.au/Journals/Wills_Journals/Wills_Journal_of_a_trip.htm. Interestingly, the first entry does not appear in its complete form in the version of Will's journal published by his father in 1863. The second part does appear in full on p. 302 (Wills, Wills, and Farmer 1863).
 10. Assembled from several sources (Earl and McCleary 1994, McCleary and Chick 1977, Earl 1996) and Phoenix's views at <http://burkeandwills.slv.vic.gov.au/ask-an-expert/did-burke-and-wills-die-because-they-ate-nardoo>.
 11. My account is drawn almost entirely from Goodwin's (2008) recent book, with supplement material on the Karankawa from other sources, including www.tshaonline.org/handbook/online/articles/bmk05.
 12. Sadly, this heroine arrived at the mission in Santa Barbara only to find herself still isolated, because no one could speak her language. All of her fellow Nicoleños had died of disease or disappeared. She lasted only a few weeks herself, despite much care and attention. My account is drawn from several sources (Hardacre 1880, Hudson 1981, Morgan 1979, Kroeber 1925). This true story was the basis for the well-known novel by Scott O'Dell, *The Island of the Blue Dolphins*. The quoted phrases come from Hardacre's 1880 article in *Schribner's Monthly*.

Chapter 4. How to Make a Cultural Species

1. Boyd and Richerson (1985) built on the pioneering efforts of Luca Luigi Cavalli-Sforza and Marc Feldman (1981), who led the way in modeling cultural evolution as a separate process from genetic evolution. Other key contributors to this early work on this issue include Durham (1982), Sperber (1996), Campbell (1965), Lumsden and Wilson (1981), and Pulliam and Dunford (1980). Intellectual threads can be traced back to James Mark Baldwin (1896). For valuable and insightful overviews see Hoppitt and Laland 2013, Brown et al. 2011, Rendell et al. 2011.
2. Most of the items in this list are covered at some point in this book. For those that are not, see judgment heuristics (Rosenthal and Zimmerman 1978), standards of punishment (Salali, Juda, and Henrich, 2015), and gods/germs (Harris et al. 2006).
3. See Bandura and Kupers 1964.
4. See Henrich and Broesch 2011.
5. For these hunting examples, see Henrich and Gil-White 2001.
6. At the University of British Columbia, I was a faculty member in the Department of Economics and the Vancouver School of Economics for nearly a decade. I've also taught MBAs in NYU's Stern School of Business and been a visiting professor at the Business School at the University of Michigan. Consequently, I'm familiar with both MBAs and economists.
7. See Kroll and Levy 1992.

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8. See Henrich and Gil-White 2001, Rogers 1995b, Henrich and Broesch 2011, and N. Henrich and Henrich 2007: chapter 2.
9. Evolutionary models predict that cultural learning should dominate when individual learning is difficult or costly and when learners are uncertain (Hoppitt and Laland 2013, Laland, Atton, and Webster 2011, Laland 2004, Boyd and Richerson 1988, Nakahashi, Wakano, and Henrich 2012, Wakano and Aoki 2006, Wakano, Aoki, and Feldman 2004).
10. Thanks to Michael Muthukrishna for pointing this out. See www.forbes.com/sites/moneybuilder/2013/11/14/investing-with-billionaires-the-ibillionaire-index/.
11. See Pingle 1995, Pingle and Day 1996, Selten and Apesteguia 2005, N. Henrich and Henrich 2007, Fowler and Christakis 2010, Apesteguia, Huck, and Oechssler 2007, Offerman, Potters, and Sonnemans 2002, Offerman and Sonnemans 1998, Rogers 1995a, Conley and Udry 2010, and Morgan et al. 2012.
12. Work on cultural learning has a long history in psychology (Rosenbaum and Tucker 1962, Baron 1970, Kelman 1958, Mausner 1954, Mausner and Bloch 1957, Greenfield and Kuznicki 1975, Chalmers, Horne, and Rosenbaum 1963, Miller and Dollard 1941, Bandura 1977). See Henrich and Gil-White 2001 for discussion and review.
13. Mesoudi and O'Brien 2008, Atkisson, O'Brien, and Mesoudi 2012, Mesoudi 2011a.
14. This experiment comes from Kim and Kwak (2011). One might worry that in this particular experiment the stranger was more active than mom, which might have biased the infants' referencing toward the stranger. However, related work with Swedish (Stenberg 2009) and American (Walden and Kim 2005) infants allays these concerns.
15. This is from Zmyj et al. 2010, but also see Poulin-Dubois, Brooker, and Polonia 2011, and Chow, Poulin-Dubois, and Lewis 2008.
16. In one now paradigmatic experiment, Kathleen Corriveau and Paul Harris (2009b) exposed three- and four-year-olds to two potential models (adults) who gave their opinions regarding the names (linguistic labels) of four common things, like ducks and spoons, with which the children would already be familiar. One of the models accurately named all the items, while the other gave incorrect labels. Then the young subjects saw the potential models name a novel object that was unfamiliar to the children. Having heard both models give different object labels, the kids were asked to label the object. Whom should they believe? It turns out that not only do kids track who is a competent labeler of things in providing their label for the object, but they also remember this information for at least a week: when the same children were retested a week later, without hearing the models label familiar objects again, the children still copied the labels used by the previously more accurate person. The reader should also see Koenig and Harris 2005, Corriveau, Meints, and Harris 2009, Scofield and Behrend 2008, and Harris and Corriveau 2011 on word learning, and Birch, Vauthier, and Bloom 2008 for artifact-function learning. Young children also prefer to learn from more confident models (Birch, Akmal, and Frampton 2010, Jaswal and Malone 2007, Sabbagh and Baldwin 2001).
17. See Henrich and Gil-White 2001 for a review.

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18. This experiment is drawn from Chudek et. al. 2012. On adults, see Atkisson, O'Brien, and Mesoudi 2012.
19. A sampling of evidence for same-sex cultural learning biases comes from Bussey and Bandura 1984, Bussey and Perry 1982, Perry and Bussey 1979, Basow and Howe 1980, Rosekrans 1967, Shutts, Banaji, and Spelke 2010, Wolf 1973, 1975, Bandura 1977, Bradbard et al. 1986, Bradbard and Endsley 1983, Martin and Little 1990, and Martin, Eisenbud, and Rose 1995. For recent work in six- to nine-month-olds, see Benenson, Tennyson, and Wrangham 2011.
20. For research on language and dialect cues, see Kinzler et al. 2009, Kinzler, Dupoux, and Spelke 2007, Shutts et al. 2009, and Kinzler, Corriveau, and Harris 2011. Children (Gottfried and Katz, 1977) and adults (e.g., Hilmert, Kulik, and Christenfeld 2006) also seem particularly disposed to learn from those who share their existing beliefs. See Buttelmann et al. 2012 for evidence of selective imitation in infant using ethnic cues (language).
21. Drawn from Hoffmann and Oreopoulos 2009 and Fairlie, Hoffmann, and Oreopoulos 2011, but also see Nixon and Robinson 1999, Bettinger and Long 2005, and Dee 2005.
22. For experimental work in children supporting the effects of age and age vs. competence tradeoffs see Jaswal and Neely 2006 and Brody and Stoneman 1981, 1985. Children can use age in sophisticated ways, sometimes using it as cue to competence, and other times deploying it as a self-similarity cue (VanderBorghet and Jaswal 2009, Hilmert, Kulik, and Christenfeld 2006). On the acquisition of food preferences, see Birch 1980 and Duncker 1938. For infants, 14- to 18-month-olds more closely imitate the actions of models that are nearer to them in age (Ryalls, Gul, and Ryalls 2000).
23. Research in small-scale societies examining how senior status influences cultural transmission is only just beginning—see work in the Bolivian Amazon by Reyes-García and colleagues (2008, 2009) as well as my work with James Broesch in Fiji (Henrich and Broesch 2011). However, anthropological ethnography across diverse societies reveals a clear association between age and prestige, and prestige has potent effects on cultural learning. Chapter 8 explains how the rate of change in society influences the link between age and prestige, which explains why the elderly are not particularly prestigious in our own societies.
24. Morgan et. al. (2012) and Muthukrishna et al. (forthcoming) provide the best current evidence of conformist transmission in humans, though also see Efferson et al. 2008, McElreath et al. 2005, 2008, Rendell et al. 2011, and Morgan and Laland 2012. On conformist transmission in fish, see Pike and Laland 2010. For an entry into the theoretical modeling literature, see Nakahashi, Wakano, and Henrich 2012 and Perreault, Moya, and Boyd 2012. This modeling work suggests we should find conformist transmission in many species reliant on social learning.
25. For cross-national data, see: on United States, Stack 1990; on Germany, Jonas 1992; and on Japan, Stack 1996. For evidence of prestige and self-similarity effects as well as copying methods, see Stack 1987, 1990, 1992, 1996, Wasserman, Stack, and Reeves 1994, Kessler and Stipp 1984, and Kessler, Downey, and Stipp 1988.
26. For an overview, see Rubinstein 1983. For evidence from the United States of adolescent epidemics, see Bearman 2004.

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27. See Chudek et al., n.d., Birch and Bloom 2002, Barrett et al. 2013, Scott et al. 2010, Hamlin, forthcoming, Tomasello, Strosberg, and Akhtar 1996, Harris and Corriveau 2011, Corriveau and Harris 2009a, Koenig and Harris 2005, Buttelmann, Carpenter, and Tomasello 2009, and Hamlin, Hallinan, and Woodward 2008.
28. See Byrne and Whiten 1988 and Humphrey 1976.
29. Humphrey (1976) sketched both the Machiavellian intelligence hypothesis (Byrne and Whiten 1992) and the cultural intelligence hypothesis (Herrmann et al. 2007, Whiten and van Schaik 2007).
30. See Schmelz, Call, and Tomasello 2011, 2013, Hare et al. 2000, and Hare and Tomasello 2004.
31. See Heyes 2012a. Of course, showing that something can be influenced by experience doesn't tell you much at all about whether its development has been fostered or shaped by natural selection.
32. See Heyes 2012b.
33. See Whiten and van Schaik 2007 and van Schaik and Burkart 2011.
34. One of the debates in this literature involves opposing "innate" and "learned" in explaining our abilities and behaviors. As we'll see, much behavior is both 100% innate and 100% learned. For example, humans have clearly evolved to walk on two legs, and it's one of our species' behavioral signatures. Yet we also clearly *learn* to walk. From natural selection's point of view, it only cares that the phenotype it "wants" emerges when it needs it. To get there, it will use learning, attention biases, motivational changes, anatomical adjustments, inferential biases, and pain responses to make sure that the required developmental processes run to completion, on schedule. Thus, showing that something is learned only tells us about the developmental process but not about whether it was favored by natural selection acting on genes. For example, many people throughout history have had to figure out sexual intercourse on the fly, with no information from other people, so they clearly had to learn about it for themselves. Yet, to suggest that it has not been shaped by natural selection seems unlikely, despite the importance of learning in the process. To canalize learning about intercourse, natural selection made some things "feel right" and other things not so much. Consequently, most couples can eventually figure out what to put where and for how long, at least well enough for natural selection's purposes. Despite the importance of learning for both walking and sexual intercourse, there are no remote societies studied that only hop or crawl or that don't make babies. For evidence of differences among human populations in cultural learning, see Mesoudi et al. 2014.

Chapter 5. What Are Big Brains For? Or, How Culture Stole Our Guts

1. See Tomasello 1999. Other important recent efforts to understand the role of cultural evolution and its influence on genetic evolution are Sterelny 2012a and Pagel 2012.
2. See Roth and Dicke 2005, Lee and Wolpoff 2002, and Striedter 2004.
3. The data in figure 5.2 are drawn from Miller et. al. 2012. I averaged the fractions

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WHEN WE CROSSED THE RUBICON

The crucial event in the history of our species involved crossing the threshold into a regime of cumulative cultural evolution, which has driven human genetic evolution ever since. This is the process that made us uniquely human, but I have not said much about when our lineage made the crossing. When did our ancestors first begin to possess bodies of know-how or tools of sufficient complexity that no single individual could have invented it from scratch on his or her own in one lifetime?

Well, first, there's no reason to suspect it was a singular moment or event. Instead, our lineage probably danced around the starting line for a long time. One group would cross the threshold and begin to very slowly accumulate cultural know-how, only to have those cultural products lost when the group was broken up or decimated by environmental shifts, diseases, or conflicts with nearby groups. Setbacks would also result from migrations to new environments or environmental changes, because any emerging cultural adaptations might not fit the new circumstances or the relevant materials or resources might not be available. For example, groups might learn to control—but not start—fires for cooking. Once they move away from their natural fire sources and their fires go out in a rainstorm, that's it, no more fire. Or a little cumulative cultural evolution might create a nice stone chopper made from a certain kind of volcanic rock, but once the group migrated to a new region, perhaps driven there by climatic shifts, they'd lose access to that type of rock and eventually forget how to make those choppers. With low-quality imitative abilities, error-prone copying, social intolerance,

and little or no teaching, accumulating and sustaining cultural adaptations would have been very delicate in the early days. So, when were these early days?

To triangulate in on them, we have three main lines of evidence. Studies of living apes, when used with care, can help us make inferences about what our last common ancestor with chimpanzees was like. That's our starting point. From there, we rely on detailed analyses of the stones and bones unearthed by paleoanthropologists, which permit us to infer aspects of the lives and abilities of our ancestors and how these have changed through time. Finally, comparative studies of genes from humans, apes, and even ancient DNA taken from bones helps us figure out which genes have changed and how they've changed. From analyses of these stones, bones, and genes, we'll look for evidence of cumulative cultural evolution and map out a crude—and *admittedly quite speculative*—time line.

Let's start at the beginning: how cultural was our common ancestor with chimpanzees? Genetic evidence indicates that our lineage split from the line leading to chimpanzees between 5 and 10 million years ago. Since neither chimpanzees nor any other primate have any significant cumulative culture, it's a good bet that our last common ancestor also lacked cumulative culture and wasn't any more cultural than modern chimpanzees. The upshot of this is that we can immediately put down a bookend: our last common ancestor with chimpanzees who lived 5 to 10 million years ago had not crossed the threshold to cumulative cultural evolution.¹

After about 4 million years ago, the bones tell us that an ape that walked on two legs with a brain somewhat larger than a chimpanzee appeared in Africa. There are a number of species of these apes, but for simplicity, I'll refer to them collectively as *Australopiths*. We don't have tools that can be directly and uncontroversially connected to these guys, but we do have three kinds of indirect evidence: (1) their brain size combined with data on what bigger brains usually imply for primates, (2) cut marks made by stone tools on animal bones, and (3) anatomical changes in their hands, which fit into the account I developed in chapters 5 and 13 on the coevolution of tools and dexterity.²

Let's start with brain size. Both field and laboratory studies suggest that primates with larger brains are better at individual learning, social learning, and several other cognitive skills. Among large-brained apes like chimpanzees and orangutans, this research suggests that greater social learning leads to more frequent tool use. Young chimpanzees are

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more likely to learn to use probes to extract termites, ants, and honey from otherwise difficult-to-access locations and to use stone or wooden hammers to crack nuts open, if they can be with others who are doing these activities. At least one group of chimpanzees even adds a “brush head” to stick-probes that helps them to more efficiently extract termites. Since Australopiths had somewhat bigger brains than chimpanzees (440 cm³ vs 390), we can infer that Australopiths were better at social learning and were thus probably using more tools, more often, and in more kinds of tasks than any living ape. Tool use by Australopiths was also likely enhanced by the fact that they were primarily ground dwellers (discussed in chapter 16) who walked comfortably on two legs, instead of knuckle-walking like living apes, so they would have had an easier time carrying tools around.³

About 3.4 million years ago in Ethiopia, somebody was using stone tools to cut and scrape the meat off a cow-sized ungulate (like a horse or zebra) and a goat-sized bovid (think baby antelope). Stones were also used to smash open bones to get at the rich and nutritious marrow inside. Based on the current evidence about who inhabited this region of Ethiopia at that time, it was probably Australopiths doing this food processing.⁴ Now, we don’t know if these were stones used as tools or if they were stone tools—that is, stones that had been crafted to have sharp edges or other useful features. The Australopiths might have simply searched around for sharp-edged stones and used those. As a point of reference, chimpanzees do use stones to smash open nuts, but they don’t use stones to butcher the animals they kill (and they do hunt), nor do they use stones to crack open bones to get marrow. They also don’t get access to anything the size of a cow, so they hunt only small game. I will be summarizing these pieces of evidence in table 15.1 as I go along.

Roughly 200,000 years later, fossils from an ancient hand suggest that the use of such stones as tools may already have been at work shaping the evolution of the anatomy of some Australopith species, tinkering away via natural selection to improve their “precision grip.” This is the delicate grip—between our thumbs and fingers—that we use to carefully manipulate tools. It’s the configuration that allows us, but not other apes, to thread a needle and to effectively craft stone tools, which were soon to appear in the paleoarcheological record. Unlike chimpanzees, the thumbs of (at least) some Australopiths had lengthened and the fingertips had widened, which substantially improves the precision grip. The bones also show an attachment area for a muscle called the flexor pollicis longus. This muscle, which strengthens the thumb when

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flexing, is either missing or underdeveloped in living apes. Alongside these changes are others that stabilized, strengthened, and honed the precision grips of Australopiths, including adjustments that gave their hands the distinctive human ability to “cup” and to perform other kinds of grasping movements that apes cannot.⁵ These anatomical adjustments in Australopiths appear to be a coevolutionary response to a world in which making and using tools is already more important than anything we see in living apes.⁶

Of course, we need to remain skeptical. This need not be culture-driven genetic evolution. The tools that drove this evolutionary change in the hands of our ancestors may be purely a product of individual smarts—maybe each Australopith is figuring out how to make tools by himself or herself, and social learning played no role. This is possible, but it would mean these apes were unlike both other living apes and humans, whose use of tools, even simple ones, is increased by social learning.

By 2.6 million years ago, the first stone tools appear in the paleoarcheological record. Known as Oldowan tools (after Olduvai Gorge in Tanzania), these are not just stones used as tools, but stones crafted and shaped to be choppers, scrapers, hammerstones, and awls. Detailed analyses and experiments that involve making and using new versions of these tools suggest that different tools were variously specialized for cutting the meat off of large mammals, breaking bones open to access the marrow, scraping hides, cracking nuts, and slicing through tough grasses or reeds. The remains of animal bones left at these sites make it clear that these guys weren’t just messing around. They were butchering giraffes, springboks, buffalos, and even the occasional elephant. These tools were made from a variety of stone materials, including obsidian, limestone, and quartz, which were often transported 10 to 20 kilometers from their source.⁷

Keep in mind as I go along that I’m giving the current earliest dates for these tools and anatomical changes. Since the chances that researchers happened to find the actual earliest case of anything is for all practical purposes, zero, we can be fairly confident that whatever we are talking about probably emerged before the date given.

The earliest Oldowan tools don’t look impressive, but they are deceptively difficult to learn to make well. The percussive blows used to make them require accurate and powerful targeting at the correct angle. Skilled Oldowan toolmakers, even at this primitive level, needed to have mastered multiple techniques with different materials, including the

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**Table 15.1. Evidence Relevant to the Beginnings
of Cumulative Cultural Evolution**

Millions of years ago	Inference to abilities	Evidence	Implication	Most likely species
3.4	Use of stones as tools to process game	Cut marks from stone tools on animal bones	Tools used for butchery in a more sophisticated way than by any living ape	Australopiths
3.2	Emergence of precision grips for tool use	Anatomy of hand bones	Sufficient reliance on tool use to drive anatomical changes	Australopiths
2.6	Fracturing techniques for making stone tools ("Oldowan tools")	Intentionally shaped stones and bones with cut marks	Substantial food processing, with tools used for butchery as well as cutting grasses and sawing wood	Early Homo or Australopiths
2.3	Larger brains with improved sequential and hierarchical processing for tools, language, etc.	Larger crania that show development in Broca's cap	Increasingly complex cultural practices demanding more sophisticated abilities	Early Homo
2.0	Brain lateralization—hemispheric division of labor beginning to emerge	Stone tools made by right-handers	Demands being placed on brains for learning tools and communicative repertoires	Early Homo
1.8	Sharpened bones as tools to access termites, etc.	Detailed use-wear analyses of bones	Access to high-quality food sources and possession of non-stone technologies	Australopiths or Early Homo
1.8	Bigger brains, better at acquiring, organizing and transmitting culture	Larger crania (800 cm ³)	Increasing dependence on culturally acquired know-how	<i>Homo erectus</i>
1.8	Ability to move into and adapt to diverse, novel environments	Skulls found in Asia and the Caucasus	Reliance on cultural evolution to adapt to novel environments	<i>Homo erectus</i>

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Table 15.1. (cont.)

Millions of years ago	Inference to abilities	Evidence	Implication	Most likely species
1.8	Dependence on food processing, possibly some cooking	Smaller teeth, jaws, and guts; facial shortening	Cultural know-how to find, extract, and process high-quality foods driving anatomical changes	<i>Homo erectus</i>
1.8	Accurate and fast throwing abilities, with practice	Anatomical changes in shoulders and wrists	Cultural transmission facilitating the acquisition of throwing skills, which in turn shape anatomy	<i>Homo erectus</i>
1.8	Long-distance endurance running or scavenging	Anatomical changes	Requirement for water containers and tracking skills	<i>Homo erectus</i>
1.75	Fancier tools: techniques for creating large stone slabs	Large hand axes, cleavers, and picks	More controlled force and the production of large “blanks”	<i>Homo erectus</i>
1.7	Greater reliance on acquiring and processing high-quality foods	Narrowing of the pelvis and reduction of cheek teeth	Techniques for the acquisition and processing of meat, marrow, and underground roots/tubers	<i>Homo erectus</i>
1.6–1.2	New techniques, materials (stone types and bone) and standardization	Variety of large hand axes, cleavers, and picks	More refined tools worked on both sides, with greater symmetry and edge thinning	<i>Homo erectus</i>
1.4	Better precision grip	Changes in finger bones	Sufficient tool use to drive emergence of modern hands	<i>Homo erectus</i>
0.85	More sophisticated techniques for making stone tools	3D symmetry and tool thinning	Soft-hammer techniques and more-complex procedures	<i>Homo erectus</i>
0.75	Knowledge of cooking, quarrying, plants, fish, and turtles	Hearths, animal and plant remains, tools, big slabs	Dependence on substantial cultural know-how	<i>Homo erectus</i>

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ability to repair stone cores, which are routinely damaged during the manufacturing process. Even when tutored by human experts and motivated by the need for a cutting edge to access some food, apes cannot learn to make stone tools in the manner, or with the skill, of the Oldowan toolmakers. The famous language-trained bonobo (a type of chimpanzee), Kanzi, was given stones and shown the Oldowan technique by an expert human stone knapper. Kanzi, however, lacked the dexterity to use the technique, so he invented his own approach, which involved using his full force to smash the stone into the floor or another stone. He would then search the refuse for any stone pieces with a sharp cutting edge. These edges got the particular job done that he wanted, but analyses of the stone assemblages he created show they lack many of the key features of Oldowan stone tools.⁸

By around 2.4 million years ago, a bigger-brained (about 630 cm³) bipedal ape appeared in Africa. These apes, and there may have been more than one species, are typically considered the first members of our genus, *Homo*, so I'll refer to them collectively as Early Homo. Early Homo had smaller jaws and cheek teeth, which had thinner enamel. These characteristics suggests that their anatomy was responding to the spread of know-how about food processing, of which those Oldowan tools likely played a role. Stone tools probably accompanied wooden tools, which were part of a body of cultural expertise. Such know-how would have facilitated locating and digging up underground tubers and roots, scavenging and processing (cutting, chopping, and pulverizing) meat and bone marrow, and finding and extracting termites, ants, eggs, rodents, and honey. Knowledge of seasonal spawning, along with clubs and simple spears, may have permitted Early Homo to obtain large fish, because fish bones appear in many early sites. Similarly, turtle shells suggest that Early Homo may have figured out how to "flip" turtles and then penetrate their shells. The access to, and processing of, these richer resources would have opened the door for brain expansion, as new energy sources became available and less energy was needed for the grinding, cutting, and chopping done by big teeth and jaws, or for the slow breakdown and digestion that occurs in the mouth, stomach, and small intestines.⁹

At some point during this early phase, the gene *MYT16* probably got switched off in our lineage by a mutation on chromosome 7. In living primates, this gene helps build the massive muscles that wrap around primate skulls and allow them to chew tough foods and to bite really hard. In humans this gene is deactivated, because we no longer need the

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high-powered muscle fibers that it helps build. This genetic deactivation would have been selected for in an ape only if that ape had the tools and techniques for acquiring high-quality foods or for processing them (using stone choppers), as well as for offense and defense (spears, clubs), thus making those big jaw muscles merely extra baggage. Because such muscles are costly to maintain, natural selection will drop them if it can—if it has another solution.¹⁰ Australopiths are interesting in this domain because some species, which coexisted with Early Homo, developed massive jaws and teeth. This change suggests that natural selection solved a similar food-processing problem in later Australopiths—via powerful jaws and teeth—that cultural evolution was solving in Homo.

There is reason to suspect that the overall body of technical skills and know-how was actually much larger than merely making and using stone tools. By 1.8 million years ago, it appears that someone was using bones and horns as tools, perhaps even sharpening these on stones. Careful analyses of the wear on these bones suggests that they were likely used for digging, which probably included opening up termite mounds and excavating subterranean roots and tubers. Some appear polished, possibly having been rubbed against an animal hide. To be clear, these are not the finely crafted bone implements that later signal a rapidly expanding body of Paleolithic cultural knowledge.¹¹ Nevertheless, they do suggest that the accumulation of “bone know-how” began early. These bits of evidence also point to what I think is an obvious inference: both Early Homo and at least some Australopiths must have had a rich repertoire of tools made from wood, reeds, and hides, not to mention other kinds of socially learned expertise.

Amazingly, we can also make some inferences about the ancient brains of our ancestors around 2 million or more years ago. Analyses of Oldowan tools suggest that 90% of these toolmakers were right-handed. This is odd because apes don’t have a preferred hand, and our handedness comes from a division of labor between our brain hemispheres, with the left half focusing on language and tool use in most people. Consistent with this, Early Homo skulls tentatively suggest an expansion in regions known to be important for speech, gesture, and tool use and show an emerging physical separation between the hemispheres. It seems the neurological division of labor that characterizes modern human brains may have already begun to emerge in a pattern consistent with a culture-driven response to the presence of tools and the synergy between tools for things like processing food and those for communicating.¹²

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Let's return to our interspecies game of Survivor from chapter 1. Would you have known how to knap stone flakes to aid you in cutting the tough hide and thick tendons on an animal carcass? Would you have known which type of rock to use and where to find it? You can't just pick up any old rock, and chunks of flint, quartzite, and chert are not usually just lying around.

Experiments show that humans are massively aided by opportunities for cultural transmission in learning to make stone tools. However, I suspect that given enough free time and motivation, you could eventually figure all this out. This means that this skill alone is probably not cumulative cultural evolution, at least for us modern humans, since the products of cumulative cultural evolution are sufficiently complex that single individuals cannot figure them out in their lifetime. Of course, it would still be much less costly for you if you could learn from an expert. Nevertheless, for our small-brained ancestors, such tools and techniques would probably have been much harder to figure out by themselves, so these might have constituted cumulative cultural products.¹³

In this light, Oldowan tools might have persisted and at times been widespread because they were usually socially learned *and* possible for a single individual to occasionally invent on his own. What unifies Oldowan tools as a type is the use of an artificial (conchoidal) fracturing technique on certain stone types. Under the right conditions, with the right types of stone around, it's plausible that smart, terrestrial apes would have figured out this technique. Once produced, other individuals could then have acquired it by social learning, making it more common. The tools persisted through time because, even though populations may have collectively lost the technique and know-how from time to time, someone would soon have reinvented them, and then they could spread locally again. This process could have happened repeatedly.

My sense is that, at this point, we are seeing populations that were dancing on the threshold of cumulative cultural evolution. Forms of social learning were probably important to them for acquiring skills and know-how, and the consequence is that groups had much more know-how than they would have had without such learning. At this stage, social learning may have permitted individuals to acquire different kinds of adaptive know-how, about things such as making stone tools, sharpening bones, and locating key resources (like spawning fish or nesting turtles), than they could have otherwise acquired on their own. But such learning didn't yet permit the sustained accumulations

that generate sophisticated tools or complex cultural packages. Any particular cultural adaptation could be figured out in one lifetime, but all of them probably couldn't.

Accumulations come—two steps forward—but then they go—two steps backward—because groups split up, environmental shocks hit, or bad luck strikes. If this is the case, we should expect the archeological record to show variation among sites, with some sites revealing more-complex technologies than others; however, we shouldn't expect a continuous trend toward greater complexity over time. The former is what it would look like when groups are dancing on the threshold of cumulative cultural evolution.

Based on current readings of the Oldowan data by some researchers, this may be the case. Different groups at different times used different knapping strategies and preferred different stone types. Some groups even made superior choppers, which were sharpened to an edge by flaking both sides. But any trend of improvement over time in stone tools is somewhere between fuzzy and nonexistent from 2.6 million years ago to roughly 1.9 million years ago.¹⁴

By 1.8 million years ago, selection pressures generated by culture-gene coevolution had intensified, and the pace of change picked up. In Africa and then rapidly across Eurasia, a new species of the genus *Homo* was on the move with bigger brains (800 cm³); a much more modern physique, including a narrower pelvis and longer legs; and often fancier stone tools. For simplicity, I will refer to all varieties of this guys—whether in Asia, Africa, or Europe—as *Homo erectus*.

The anatomy of *Homo erectus* indicates that he'd become dependent on food processing, as discussed in chapter 5. Compared to Early Homo, his cheek teeth, face, and jaws are smaller, all of which indicates that he had less tough chewing to do. Stomachs and intestines don't fossilize, but rib cages and the surrounding bones sometimes do. *Erectus* had a barrel-shaped rib cage like us, which is unlike the funnel-shaped rib cages of chimpanzees and gorillas. This anatomy implies that *erectus* had lost the large guts that apes have and use to digest the raw foods they eat. Thus, *erectus* was becoming increasingly addicted to some combination of the high-quality, hard-to-get, processed foods our species depends on. The cultural products that facilitate this evolutionary change likely included (1) the weapons, strategies, and skills for hunting and scavenging large game; (2) the manufacturing skills, tools, and know-how for butchering big animals; and (3) the knowledge and techniques to locate and unearth underground tubers and roots or obtain honey. There's also a

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good case to be made that *erectus* had some control of fire and perhaps cooked. How often and how much *erectus* depended on fire is a running debate, but there's some evidence of fire by around 1.5 million years ago, better evidence at 1 million years ago, and good evidence of both cooking and fire at around 800,000 years ago.¹⁵

In Africa, *Homo erectus* co-emerges in the paleoarcheological record with new large stone tools, which are distinct from Oldowan tools in that the former required that large stone slabs of certain materials be quarried. Once these "blanks," as they are termed, are created, they can be worked on one or both sides to produce hand axes, cleavers, and picks. Making these tools was getting pretty complex, especially if you include locating the stone (which is often far away), quarrying and transporting the large blanks, and then actually crafting the axe, cleaver, or pick. Just the final part, knapping the blanks, seems to require hundreds of hours for modern humans to learn, even with help. It's far from clear how often an individual could figure all this out on their own in a lifetime. Despite their larger brains, lost European explorers in need of cutting edges didn't just quickly whip up some stone hand axes. In small-scale societies, populations that still make stone tools, which have been studied by anthropologists, rely on years of both cultural transmission and individual practice to make quality stone axes or adzes. And precisely how one quarries those large stone blanks is not obvious, to say the least.¹⁶

During this period, anatomical changes in the shoulders and wrists of *Homo erectus* suggest the emergence of powerful throwing abilities, a skill useful in hunting, scavenging, and attacking other people. Only humans can throw fast and accurately. By contrast, although chimpanzees do occasionally throw stuff, their tosses are slow and usually inaccurate compared to their physically weaker cousins (us).¹⁷ However, since early throwers probably threw rocks and simple spears, it's not immediately obvious that the evolution of the anatomical adjustments for throwing would have been powerfully spurred by cultural evolution. However, here's the thing: humans don't automatically develop powerful and accurate throwing. People who don't practice throwing while growing up, like most girls in my elementary school, turn out to be rather bad throwers as adults. Now imagine that you are a child growing up in a world where no one throws things, or when they occasionally do, their throws are slow and off target. You might experiment with throwing rocks or sticks at small game or birds, but you'd very likely miss, get frustrated, and give up to pursue some more fruitful av-

enue. But if you could watch and emulate older models who successfully brought down birds with fast and accurate pitches, you'd be more likely to persevere through a long period of practice. You also might notice some of the older kids engaging in target practice, which you could copy. Of course, these observations will influence you only if you are a keen cultural learner. To get a throwing tradition off the ground, one or a few unusual or lucky individuals would have to persevere through the practice period without relying on cultural learning, but that's a much less demanding requirement than needing everyone to develop throwing on their own. So cultural evolution could have created conditions favorable to throwing as a learned practice without having to first create fancy projectiles.

Similarly, as described in chapter 5, the presence of a combination of know-how related to animal behavior and tracking, as well as the making and use of water containers, may have opened the door for *erectus* to engage in long-distance persistence hunting or scavenging. Although some of the anatomical adaptations for endurance running appear in Early Homo, *erectus* is loaded with them, including most notably long legs, narrow hips, a large butt, and better heat loss from the head.¹⁸

Things accelerated from 1.6 to 1 million years ago, as new techniques and materials increasingly appeared among the remains of *erectus* societies. Hand axes, including those from the same site, go from mostly worked on one side (unifacial) to being worked on both sides (bifacial). These axes got more refined over time, showing greater symmetry and sharper edges, and are sometimes made of large bones (see figure 15.1).¹⁹ Experimental efforts by modern stone knappers reveal that these ancient tools imply the spread of new techniques that were being added to an expanding knapping repertoire. The new techniques require more-complex recipes, including procedures that prepare the stone for knapping.²⁰

As one would expect if cumulative culture was just emerging, there were both variations in techniques and practices across sites, but also uneven accumulations, with technological disappearances being common. Sometimes, even frequently, the large and distinctive hand axes vanished from the record, leaving only simpler stone tools (Oldowan).²¹ Populations could lose techniques and their associated tools if they lost contact with the relevant raw materials for a generation or two. And, as with other cultural adaptations, we also should expect fire control and cooking to drop out of the repertoire of specific groups for periods of time. As noted earlier (chapter 5), the knowledge of how to

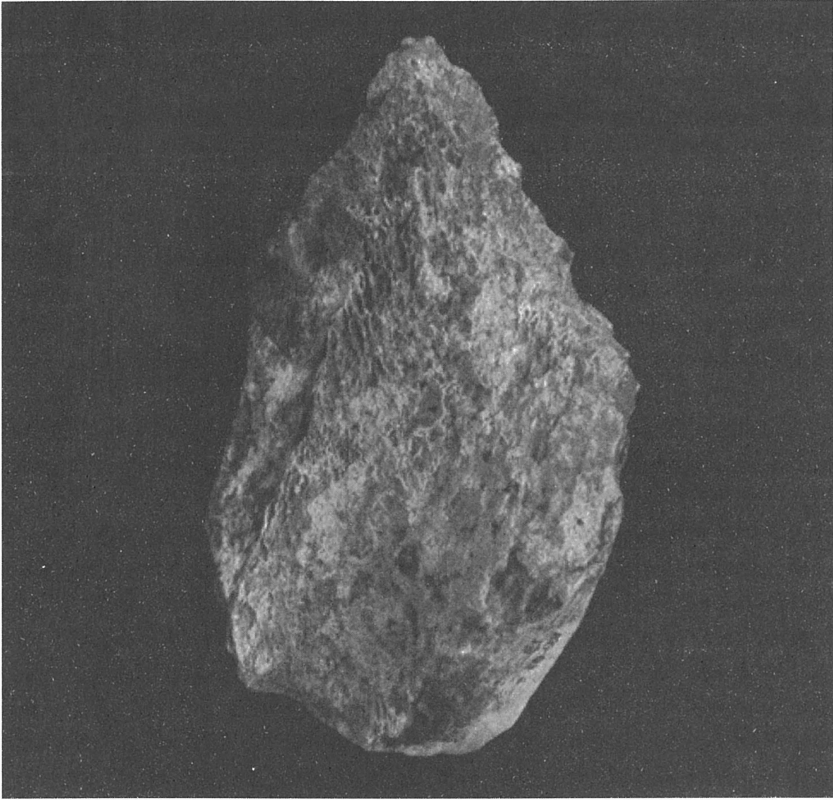


Figure 15.1. Hand axe made from mammalian long bone from 1.4 million years ago (Ethiopia).

make fire even occasionally dropped out of the repertoire of modern hunter-gatherers.

By 1.4 million years ago, anatomical evidence from fossil finger bones indicates another response to the increasing importance of tools and new tool-related techniques on our lineage's fine dexterity and precision grip. The base of *erectus*'s middle finger had been reshaped to be indistinguishable from ours and different from that of both living apes and the Australopiths. The new design stabilizes the joint during a precision grip, and reinforces the whole hand and wrist.²²

Although researchers have long argued for an immense period of stasis in the tools and know-how of *erectus*, the emerging evidence is beginning to indicate that this may not be the case.²³ By 850,000 years ago, *erectus*, now with a bit larger brain, is sometimes thinning his large

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cutting tools and creating greater symmetry. Efforts to reconstruct the techniques used in preparing these beautiful tools suggest the use of a soft-hammer technique, which would have required first making a soft hammer out of bone or antler. Such a change would have required the use of longer procedures, with more steps, and greater technical skill. A bit later, it also appears that different sites used different manufacturing methods and quite different materials to achieve the same ends.

After about 900,000 years ago, the pace of environmental fluctuations picked up. Based on mathematical modeling, this change should have increased the selection pressures for social learning, especially in a species already somewhat dependent on culture. However, shifting environments would have also impeded, stifled, and sometimes set back cumulative cultural evolution. As cultural evolution built adaptations attuned to local circumstances and resources, more frequent environmental shifts would have rendered these cultural adaptations useless by changing the available plants and animals, and altering local weather patterns. Populations would have inhabited environments for several hundred years, building up a suite of cultural adaptations, only to have to move or readapt after an environmental shift. Under such conditions, we should expect more-complex cultural products to pop up from time to time, but it should be patchy, with lots of fits and starts. Since fancy tools, for example, are not the direct product of *erectus*'s big brains or intelligence, any more than our fancy tools are a product of our own smarts, we shouldn't expect to see equally fancy tools everywhere he went (see chapter 12). We shouldn't expect this any more than we would expect the early European explorers who sailed across the globe after 1500 CE to have encountered societies with equal levels of technological complexity or sophistication. Generating and sustaining technological complexity requires collective brains linked by social networks and galvanized by social norms.

Nevertheless, the signature of cumulative cultural evolution seems to emerge at certain times and places. For example, between the Golan Heights and the Galilee mountains (Israel) on the shores of an ancient lake, the site of Gesher Benot Ya'aqov has yielded rich insights into the life of one society around 750,000 years ago. The extensive remains indicate the existence and persistence of hearths and areas for both stone-tool manufacturing and food processing. The inhabitants controlled fire and made a variety of stone tools, including hand axes, cleavers, blades, knives, awls, scrapers, and choppers. Made from flint, basalt, and limestone, tool manufacture was done on-site, often from giant slabs

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carried in from a distant quarry by a team. Some of the basalt slabs have notches, indicating the use of levers as part of the quarrying process. The basalt is of the highest quality and well quarried, suggesting that someone had a storehouse of know-how on the topic.²⁴

The group's diet was diverse and also would have required extensive local knowledge. The stone tools were used to process the carcasses of elephants, deer, gazelles, and rhinos as well as boars and rodents. The cut marks left on deer bones are not much different from the same marks made hundreds of thousands of years later by late Paleolithic hunters. The inhabitants of Gesher Benot Ya'aqov also, somehow, obtained freshwater crabs, turtles, reptiles, and at least nine types of fish, including carp, sardines, and catfish. Some of these fish were big, longer than a meter. On top of this, there were seeds, acorns, olives, grapes, nuts, water chestnuts, and various other fruits. This bounty included the submerged prickly water lily, which grows well away from shore. It also appears that they were cracking nuts open and roasting acorns to remove their shells and perhaps reduce the bitter tannins. They may even have made "popcorn" by roasting the seeds from the prickly water lily, as has been done for thousands of years in India and China.

Clearly, cumulative cultural evolution is up and running at this point, generating more know-how than you, me, or our lost European Explorers could have ginned up in a lifetime. If you aren't sure, go quarry some high-quality basalt slabs (you'll need a lever, I think), make a beautiful hand axe with full symmetry (remember to make that antler or bone hammer first), bring down an elephant (trust your Paleolithic instincts?), butcher the carcass (use the hand axe), make a fire or find naturally occurring flame, and then whip up a raft to paddle out and pick some prickly water lily (you can spot this plant, right?). Then, enjoy the elephant steaks and "popcorn."

Of course, this is not to imply that these ancient humans were like us, but merely that they had crossed the Rubicon and embarked on a genetic evolutionary trajectory that was primarily driven by culture and its products.

If you have any remaining skepticism that the cumulative cultural evolutionary threshold has been crossed by this point, in the next 300,000 years after the activities at Gesher Benot Ya'aqov, *Homo erectus* changed sufficiently, including a brain expansion to 1200 cm³, to justify a new species name, *Homo heidelbergensis*. This period revealed the first evidence of projectile weapons, including wooden throwing spears with

stone points, and the emergence of a variety of techniques for producing stone blades. These techniques are consistent within sites or populations but did vary between populations. Distinct tool traditions and composite tools that exploited natural glues weren't far behind. *Heidelbergensis* also appears to have had ears calibrated like humans to speech sounds, unlike other apes, which suggests that a culturally evolved spoken communicative repertoire had been hammering away at our genes (see chapter 13).²⁵ Now, many of these bits of know-how and technologies seem to drop in and out of the record and don't make a sustained an enduring appearance until the last 100,000 years. But this is just what you'd expect in a species dependent on a collective brain that was subject to shifting environments, intergroup competition, and challenging ecologies that constrained group size and fractured the social ties between bands.

The upshot of all this is that, based on current evidence, *Australopithecus* probably began to aggregate cultural information more intensively than any other living ape (except us), but that no particular tool or element of know-how was more sophisticated than an individual could invent in his or her lifetime. However, taken together, these aggregations may have at certain times and places been more than any one individual could have figured out. These populations, however, likely stood on the precipice of true cumulative cultural evolution, with slow advances and common retreats. This aggregation of cultural know-how drove the evolution of Early *Homo*, expanding his brain and reducing his teeth and jaws. By 1.8 million years ago, however, the threshold had probably been crossed, and cumulative cultural evolutionary products were driving the genetic evolution of our genus, shaping our feet, legs, guts, teeth, and brains. Albeit slow by later standards, toolkits improved and techniques were added gradually, though of course, cultural losses and technological setbacks continued, and would continue into the modern world. By 750,000 years ago at Gesher Benot Ya'aqov, there's little doubt that we are dealing with a cultural species who hunts large game, catches big fish, maintains hearths, cooks, manufactures complex tools, cooperates in moving giant slabs, and gathers and processes diverse plants.

The bottom line: cumulative cultural evolution is old in our species' lineage, dating back at least hundreds of thousands of years, but probably millions of years. Now, let's explore why it was our lineage that crossed the Rubicon.

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21. Of course, being good at self-regulation may have caused people to do other things correctly besides take the medications. See Horwitz et al. 1990 for an analysis that seeks to address these issues.
22. See Benedetti et al. 2013.
23. This experiment is from Craig and Prkachin 1978. Also, see Goubert et al. 2011 and Craig 1986. For a nice, more recent experiment showing how powerful observational learning is compared to verbal suggestions or conditioning, see Colloca and Benedetti 2009.
24. See Finniss et al. 2010, Price, Finniss, and Benedetti 2008, Benedetti 2008, Kong et al. 2008, and Scott et al. 2008.
25. See Phillips, Ruth, and Wagner 1993.
26. Results like these provide a major challenge to economic theory. The models that economists make of choices have to map people's choices onto their eventual outcomes. For example, if Herb chooses to take Drug Alpha for his back pain, an economist might assume that Drug Alpha will cure Herb with a probability p (say, 65% chance) and not cure Herb with a probability $1 - p$ (say, a 35% chance). This probability p is typically assumed to be a feature of the world. However, what I just explained in the main text is that in a real biological way p actually depends substantially on what Herb believes about Drug Alpha. There's a causal connection between Herb's beliefs about Alpha and the chances of various outcomes (cure or not) in the world. This is not some wacky special case, applicable only to a narrow range of drug choices. As we saw, it affects longevity in California and probably also influences whole industries of "traditional," New Age, and spiritual healing and health practices, not to mention fad diets and exercise routines. More important, in many places in the world, witchcraft is a widespread and remarkably stable set of beliefs. These beliefs may persist in part because they are reinforced by the operation of the placebo effect, such that perceiving others as angry or envious in the context of witchcraft beliefs actually then causes biological effects that increase the chances of illness. So, in a sense, witchcraft works.

Chapter 15. When We Crossed the Rubicon

1. For an introduction, see Klein 2009 and Boyd and Silk 2012. For inferences to the last common ancestor, see Henrich and Tennie, forthcoming. For sundry dates on our divergence from our last common ancestor with chimpanzees, see Suwa et al. 2009, Scally et al. 2012, and Klein 2009. The reason I'm using chimpanzees to set an *upper limit* on the cultural abilities of this common ancestor is because one of the selection pressures—climatic variation—that has likely made our lineage more cultural since we split may have similarly influenced other species, including chimpanzees. Much of the mathematical theory underpinning culture-gene coevolution suggests that the kind of relatively rapid environmental variation that has occurred over the last 3 million years, up to ten millennia ago, should favor a greater reliance on social learning (Boyd and Richerson 1985, 1988, Wakano and Aoki 2006, Aoki and Feldman 2014), making many species more reliant on social learning in adapting to shifting environments. Consequently, since the lineages leading to modern apes experienced these vari-

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- actions as well, they too may have evolved an increased reliance on social learning during this epoch.
2. See Klein 2009.
 3. On chimpanzee culture, see Henrich and Tennie, forthcoming; for the “brush heads,” see Sanz and Morgan 2007, 2011. On the effects of overall brain size on social learning and other cognitive abilities, see Deaner et al. 2007, Reader, Hager, and Laland 2011, Klein 2009, and Boyd and Silk 2012. On comparative brain sizes, see Klein 2009 and Boyd and Silk 2012.
 4. See McPherron et al. 2010.
 5. See Hyde et al. 2009.
 6. See Panger et al. 2002, but note that the pollicis longus tendon may have appeared earlier in *Ardipithecus ramidus* (White et al. 2009).
 7. See Klein 2009 and Boyd and Silk 2012.
 8. See Stout and Chaminade 2012. On Kanzi, see Schick et al. 1999 and Toth and Schick 2009.
 9. See Klein 2009, Ambrose 2001, Wrangham and Carmody 2010, and Boyd and Silk 2012. On fish and turtles, see Stewart 1994 and Archer et al. 2014. Note that fish may have also been used by the hominins that preceded Early Homo.
 10. See Stedman et al. 2003, 2004, McCollum et al. 2006, and Perry, Verrelli, and Stone 2005.
 11. See Backwell and d’Errico 2003, d’Errico and Backwell 2003, and d’Errico, Backwell, and Berger 2001.
 12. See Stout and Chaminade 2012, Stout 2011, Faisal et al. 2010, Stout et al. 2008, and Klein 2009.
 13. See Morgan et al. 2015.
 14. See Stout 2011, Faisal et al. 2010, Stout et al. 2010, Klein 2009, and Delagnes and Roche 2005.
 15. On the anatomical changes related to food processing, see Wrangham and Carmody 2010 and Wrangham 2009. On the use of fire, see Goren-Inbar et al. 2004, Klein 2009, and Berna et al. 2012.
 16. See Stout 2002, 2011, Beyene et al. 2013, and Perreault et al. 2013. This newer view is controversial, since many researchers have long claimed that this was a period of technological stasis. I think the reason researchers saw stasis is a lack of appreciation for the dynamics of cultural evolution, and specifically, the ways in which populations size, sociality, migration, and ecological shocks influence it.
 17. See Roach et al. 2013. The evolution of throwing *Homo erectus* probably benefited from some anatomical preadaptation in Australopiths that were byproducts of the evolution of bipedal walking or running.
 18. See chapter 5 for references.
 19. My thanks to the KGA Research Project and Berhane Asfaw for permitting me to use this image (figure 15.1).
 20. On change in early Acheulean tool tradition, see Beyene et al. 2013, and on various techniques that were added cumulatively, see Stout and Chaminade 2012 and Stout 2011.
 21. See Stout et al. 2010.
 22. Anatomically, I’m referring to the styloid process on the end of the third metacarpal (Ward et al. 2013, 2014).

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23. For evidence and discussion of temporal accumulations in complexity, see Stout 2011 and Perreault et al. 2013. As noted, this view remains quite controversial, though even fairly conservative approaches distinguish less and more complex variants of both the Oldowan and Acheulean tool industries (Klein 2009).
24. See Alpersen-Afil et al. 2009, Goren-Inbar et al. 2002, 2004, Rabinovich, Gaudzinski-Windheuser, and Goren-Inbar 2008, Goren-Inbar 2011, and Sharon, Alpersen-Afil, and Goren-Inbar 2011.
25. See Wilkins et al. 2012, Wilkins and Chazan 2012, Klein 2009, Wadley 2010, Wadley, Hodgskiss, and Grant 2009, and McBrearty and Brooks 2000. On the ears and the auditory capacities of *Homo heidelbergensis*, see Martinez et al. 2013.

Chapter 16. Why Us?

1. See Reader, Hager, and Laland 2011, Reader and Laland 2002, van Schaik, Isler, and Burkart 2012, Pradhan, Tennie, and van Schaik 2012, van Schaik and Burkart 2011, and Whiten and van Schaik 2007.
2. See Boyd and Richerson 1996.
3. By “individual learning” I’m referring to a broad class of cognitive abilities that allow individuals through their direct experience with the environment to select, on average, more adaptive behaviors or to better achieve their goals or satisfy their preferences. This is also called asocial learning. These abilities need not be either entirely “domain general” or narrowly “domain specific.” I expect them to be applicable to many problems, but not all problems.
4. See Meulman et al. 2012 for the basic argument here.
5. Admittedly, this leaves open the question of why bonobos and gorillas don’t use tools more than orangutans.
6. See Suwa et al. 2009 and White et al. 2009 on *Ardipithecus ramidus*. Ground-dwelling apes may be much older than 5 million years, but these details are not relevant for my argument.
7. On predators, see Plummer 2004 and Klein 2009: 277.
8. See Boyd and Richerson 1985, 1988, and Aoki and Feldman 2014 for evolutionary models of social learning. For papers combining theoretical and empirical insights, see Richerson and Boyd 2000a, 2000b. If environments change too quickly, say every generation or every decade, then natural selection will favor individual learning. At the other extreme, if environments are changing very rapidly, say on an hour-by-hour basis, then neither individual nor social learning can help. Natural selection will go back to favoring genes that fix on the best trait appropriately averaged across the range of environments experienced.
9. See Isler and van Schaik 2009, 2012 and Isler et al. 2012.
10. See Langergraber, Mitani, and Vigilant 2007, 2009. It is important not to overstate the implications of these data. We do not have equivalent data from other chimpanzee communities, so we shouldn’t be too confident that the pairing is being caused by the unusually large group size.
11. In addition to the effects of group size and social learning, predatory threats, especially in the form of raids from other groups, may further reduce the effectiveness of dominance competition. Too many fights and injuries from one’s competitors could leave males weakened and ill-prepared to deal with predators.